

WAR ON SCALE

MODELS FOR THE FIRST WORLD WAR BATTLEFRONT

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A RANGE OF SCALES

In an attempt to deceive German bomber planes conducting overnight air raids, French DCA (*Défense Contre Aéronefs*), decided to create a full-scale replica of the Paris agglomeration in late 1917.¹ The plan relied mainly on lighting effects to simulate the distinctive features of the urban form as seen from the nocturnal skies. In doing so, it created a displaced and illuminated target that mirrored the capital—plunged in blackout—and anticipated the *ville-lumière* of the 1920's. The 1:1 scale model of an entire city with a diameter of some 12,000 meter is probably the most extensive military modeling effort of the Great War—if not from military history. In the end, only a very small part of the spectacular plan had been realized by November 1918.

Fig. 1

In the same year 1917, Geoffrey Charles Pether created a small model of his internee accommodation in the prisoner camp of Ruhleben near Spandau. Following the decision of November 1914 to intern all British male citizens of military age, young Pether—a Heidelberg College student at the outbreak of the war—spent the entire four war years in this former horse racecourse converted to civilian internment camp—together with some 5,500 other intellectuals, fishermen, sailors and working men.² The 1:12 scale model of his barrack—a horse loose-box transformed into a cell for six internees—was created in a tiny wooden crate—27 by 27 centimeters—with hinged lid to reveal the interior. It reproduces the triple bunk beds, table, deck chair, wall shelves and coat rack of the barrack meticulously, and even features curtains and

painted wallpaper. The model was sent in for an arts and crafts exhibition held in the first week of June 1916.³

Fig. 2

Aside from demonstrating the cultural microcosm of the Ruhleben camp, the tiny scale model illustrates—when compared to the Paris replica—the diversity of scale, context, construction method and purpose of different scale models created during the First World War. Between these two extremes, a whole range of military—and other—models can be distinguished.

STRATEGY OF THE MODEL

Of course, the use of military scale models can be traced back much further in time. One of the oldest explicit examples can be found in an inscription concerning the construction in 330 B.C. of the naval arsenal of Piraeus. It describes the delivery of a scale model as one of the contractual obligations of the architects Philon and Euthydemos.⁴ The representation of conquered cities and the different stages of their besiegement, belonged to an ancient Roman tradition. In the Roman triumphal procession, both *signa* and *simulacra* of the defeated cities were paraded and exposed on the forum.⁵

During the French invasion of Italy in 1494, the possibilities of siege cannons vis-à-vis the high medieval city walls of Italian cities were fully exploited. As a result, the concept of a defense in-depth was developed, leading to the revolution of bastioned fortification. Gradually the design task of defense works was transferred from the architect to a new class of intellectual: the military engineer.⁶ For complex topographies, the *guerriers mathématiques* preferred the scale model as an instrument to calculate ballistic and logistical problems—such as earth movement during construction.⁷

In 1668, Louvois ordered to Vauban the construction of a *plan-relief* of Dunkirk, showing not only the city and its projected defense works, but also a considerable portion of the surrounding terrain within artillery

range.⁸ This model marked the start of an impressive collection of mostly 1:600 scale models of French border cities. In 1697, Vauban mentioned the existence of 144 plans-reliefs of 101 fortified cities.⁹ Other than its evident strategic value in designing defense works and siege-planning, the collection clearly expresses an ideological statement that is also evident in the Roman models: the supreme power of the central authority over its distant borders and defeated enemies. The collection was regularly updated and expanded until the Franco-Prussian War of 1870 ultimately demonstrated the obsolescence of geometrically based fortification, to a degree that the further production of the plans-reliefs for military purpose was dismissed.¹⁰

Fig. 3

In the First World War, the extensive implementation of scale models sets a new paradigm. If some of the military models discussed in the following sections may resemble their predecessors to a certain extent, some fundamental differences can be distinguished also. They share with the examples mentioned before an ideological aspect—no scale model is a neutral object. The choice of the appropriate scale determines the level of detail that can be obtained, the dimensions of the scale model and the information that can be included—or is excluded. The examples of Paris and the miniature of Ruhleben show that, from a certain scale on, the mere size of the model can transform scaled content into ungraspable abstractness or tangible objects. Paradoxically, the downsizing of urban agglomerations to plan-reliefs result in physically overwhelming models. Like the earlier examples, most models from the Great War often have a symbolic or commemorative meaning. However, in contrast to earlier examples, they have all been created within the timeframe of the hostilities. Previously, military models were constructed during the planning phase of defense works, in the preparation of a siege, or sometimes post factum as instructional models. The stalemate of the trench war, the successive technological evolutions and the changed military insights causes this new trend.

FULL SCALE REPLICAS

In the earlier mentioned case of the faux Paris, the emergence of strategic aerial bombing was catalyst for the adventurous undertaking. First airships, and from early 1918 on, long-range *Gotha* bomber planes—carrying bomb loads of 600 up to 1,000 kilograms—had killed a total of 267 people in Paris by the end of the war—causing ever-greater panic.¹¹ At the same time, air defense through the installation of barrage balloons and anti-aircraft guns, evolved in such a way that by 1917 daylight raids were considered too risky by the German High Command and were subsequently replaced by nocturnal attacks. In this context the French government commissioned French-Italian engineer Fernand Jacopozi—who's star as an expert in the lighting of public space and buildings would rise in 1925 with the lighting of the Eiffel tower as an advertisement for Citroen—to create the plan for a sham Paris and its nocturnal lighting.¹² The plan, including the layout of fictitious avenues, squares, industrial complexes, railroads and stations, consisted of three separate areas, of which the objective 'B' was the most audacious.¹³ It would visually displace the whole city center of Paris some twenty kilometers northwest to the forest of Saint-Germain-en-Laye, along a meander of the Seine bearing a certain resemblance to the river loop in the capital itself.

“Fake railway stations and fictitious squares and avenues—simulated through carefully placed lanterns in the forest of Saint-Germain-en-Laye—would have given to the enemy in the sky the illusion to fly over a poorly concealed Paris. Rolling platforms carrying storm lanterns and pulled by horses, would form “trains” entering or leaving “stations”, lit themselves by fixed lamps. On the Seine, some vaguely illuminated barges would float slowly. Thus, German pilots would take the forest of Saint-Germain-en-Laye for a “rewarding” target.”¹⁴

Fig. 4

The full implementation of the plan was aborted prematurely by the Armistice of November 1918. In fact, only a small portion of the objective “A” was completed, depicting the Gare de l' Est. It consisted of cladded

wooden structures for the buildings, painted canvas to evoke dirty glass roofs and electric lighting, simulating the dimmed lamps of a city in blackout.¹⁵

Other World War I models on a scale 1:1, mostly used for training purpose, can be found. A full scale model of a portion of the Verdun battlefield—including Fort Douaumont—was recreated at Stainville near Bar-le-Duc.¹⁶ And in the final preparation for the Zeebrugge Raid of April 1918, a part of the Mole was reconstructed to practice the assault. It was located in an abandoned chalk pit at Wouldham.¹⁷ Full scale models for observation and camouflage purpose were created often by special camouflage sections and could take the shape of a fake hollow observation tree—replacing an existing tree overnight—a watching post hidden in a haystack or even a listening post in hollowed out horse carcass.¹⁸

SANDBOX MODELS

Several extensive terrain models were laid out in the vicinity of the battlefields by British and Commonwealth troops during the later stages of the war. Meant mainly as instructional and briefing models during preparation of the great offensives, these models testify of the increasing acknowledgement by the military staff of the importance of terrain conditions. They illustrate how meticulous planning was considered key to the success of such operations. The terrain models were often surrounded by pathways—and sometimes even equipped with an observation tower—to allow a company of soldiers to study the model from different viewing angles. Created directly on the ground, their overall layout and purpose is not very different from the sandbox models that are sometimes created ad hoc during military campaigns—that is: if one makes abstraction of the overall dimensions. Considering the limited perspective of the soldier in the trenches of the First World War—where just looking over the parapet was not without any risk—and given the fact that most soldiers would never see the no man's land during broad daylight, large scale models offered a perspective that was until then the privilege of the aviators conducting reconnaissance flights.¹⁹

At least six models, all dating back to 1917 have been identified in literature or through images. One model—or maybe two models, according to the source—on a scale 1:50 was laid out on the slopes of the Scherpenberg near the village of Loker. It depicted a part of Wijtschate Ridge, showing trenches, forts, roads and woods. The model was updated on a regular basis as new German trenches were spotted.²⁰ Two other models survive through photographs: one located in an army camp at Potyze—representing the Broodseinde sector of the Passchendaele battlefield—and the other one in the Vimy Ridge sector.²¹ Some literature also mentions two models created before the Battles of Cambrai and Arras.²² Perhaps the best covered model is the one located at Petit Pont near Ploegsteert. It shows—again—Messines Ridge and the center of the town. The model seems to have been filmed and photographed officially at one point, featuring Australian war hero Captain Albert Jacka—studying trench maps in front of the model. This might explain why the pictures are framed in a way that they deny vital intelligence to the enemy, while at the same time the model is charged with ideological meaning.²³

Fig. 5

Fig. 6

The most direct reference towards these kind of models is a model of—again—Messines Ridge, constructed at the Cannock Chase military camp in Staffordshire, UK.²⁴ The model, measuring some 25 by 32 meter and scaled 1:50 in plan and 1:25 in elevation, was constructed by soldiers of the New Zealand Rifle Brigade in the summer of 1918, i.e. after the attack on Messines. Excavation in 2013 gives an impression of the remarkable level of detail. Exceptionally, this model was built as a semi-permanent construction, using a cement base layer, pebble roads, cement trenches, brick buildings and even a concrete drainage system along the contours. Its survival is probably the result of its original double intention both as an instructional and a monumental model, commemorating the contribution of the New Zealand forces in the capture of the town of Messines. After the war it became a local attraction, the last reports of visits dating from the 1960's, until the site was eventually relinquished and taken over by nature.

PORTABLE RELIEF MAPS

When in November 1914 the opposing forces found themselves facing a continuous line of entrenched positions from the Belgian coast to Lorraine, the war entered a new phase. The stalemate of the next years resulted in large offensives by the belligerents, hoping to force a breakthrough or capture strategic positions. Battlefield geology and topography proved vital to the planning of such extensive assaults as well as to the shape of the frontline. All the more in areas with low relief—being most part of the front in Flanders, Artois and Picardy—local elevations were often hard-fought.²⁵ Soon it was discovered that the maps available at the outbreak of the war (on a scale 1:60,000 – 1:126,000) lacked sufficient detail for new artillery tactics and operational planning.²⁶ When static and creeping barrage fire became common practice, batteries had to be provided with suitable barrage maps and charts in order to achieve maximum effect. Thus large-scale topographical terrain survey was carried out throughout the war in an enormous effort to calibrate and fine-tune different triangulation systems. A crucial technological leap forward in this respect was the implementation of aerial reconnaissance photographs and photogrammetry.

In addition, a considerable amount of terrain models was produced —offering the advantage of direct visual reference over maps. In December 1916, the British Ordnance Survey created a new sub-section for making relief models of the fighting areas, averaging 36 models per week by April 1917.²⁷ Such models were created for the first time at the Vimy Ridge front in early 1916—however layered models were introduced in the British army as early as 1915. The new models consisted of 1:20,000 map sheets printed on extensible paper, glued on a plaster terrain model which exaggerated the vertical scale by a factor of four.²⁸

The French and German army too used 1:5,000 and 1:20,000 scale plans-reliefs at Verdun.²⁹ In Germany, Karl Wenschow first experimented towards the end of 1918 with a pantograph featuring a milling drill in order to facilitate the reproduction of plaster models—a technique he would continue to develop

throughout the Second World War in service of the Luftwaffe.³⁰ In December 1918, the Australian army ordered for the creation of an Australian War Memorial the production of over twenty relief maps and several models depicting the Belgian and French battlefields.³¹ The relief maps were created in papier mache to which the topographical map information and grids were later on applied by hand. The other models were wood-reinforced gypsums of a clay original, painted afterwards by a landscaping artist.

Fig. 7

Fig. 8

Some special purpose models were also produced in the course of the events. Before the Third Battle of Ypres in 1917, maps were created that indicated which parts of the Gheluvelt Plateau were likely to be flooded or would collect water. In the case of destruction of the drainage system or heavy rain, these conditions would hinder the deployment of tanks and the movement of infantry and artillery. The results of this charts were kept up to date on a daily basis in a plasticine swamp model.³² For the Zeebrugge Raid, several 1:2,500 scale models—one for each platoon of around forty soldiers—had been used during the training. One wax model created by Engineer W.A. Bury was carried on the deck of HMS Vindictive during the raid.³³

Fig. 9

The serial production of terrain models for combined operations—allowing to share the mission objectives even with the lowest in rank—shows the direction that military model making would head to during the Second World War, when the use of pantographs and egg-crate mass-produced models, were commonly used.

DAZZLE TESTING THEATRES

Early 1917, with submarine warfare at its peak, excessive loss of allied shipping on the vital Atlantic routes and around the British Isles, forced British Admiralty to reconsider traditional concealing tactics. Naval painter and Royal Navy Reserve Lieutenant Norman Wilkinson proposed in April 1917 a disruptive coloration for ships that tried to maximize effect on the distance crucial for torpedo aiming from a submarine periscope. The bottom line was that in highly dynamic contexts with constantly shifting lighting and weather conditions, the actual concealing of targets would be an impossible task. The goal of dazzle painting was therefore rather to break up target contours and disclose the ship's number, direction, speed and range—thus rendering range finding and targeting more difficult through stereoscopic range finders and periscopes used at the time.³⁴ Shortly after, Wilkinson was appointed head of a new so called Dazzle Section, similarly to the French Section de Camouflage—a 3,000 men battalion of artists. Wilkinson's Dazzle Section initially consisted of a team of 5 designers, 3 model makers and 11 draughtswomen and was located in the Royal Academy of Arts in London. Other countries soon followed the British example : by November 1918, over 4,000 merchant vessels and 400 warships had been painted in unique dazzle paint patterns.

Since these designs aimed to distort the angle at which a ship would be perceived, and given the fact that the two-dimensional patterns were applied on convex ship hulls, camouflage designers relied on wooden ship models. Wilkinson's Dazzle Section used a relative simple observation device with a boxed periscope at one end of a table and background sheets at the other side. Halfway the platform was a turning table for wooden ship models on which the dazzle schemes were applied with removable paint. Different atmospheric effects could be simulated by placing more or less transparent screens in front of the periscope and by switching to different background plates.³⁵

Fig. 10

Fig. 11

A more advanced version of this testing table was constructed by Boston area camoufleurs and donated to MIT after the war—where it was used for some scientific research on the effects of camouflage. It featured adjustable metal rolls covered with painted canvas to simulate different sea textures and wave conditions, nitrogen lamps for daylight simulation and a fog device consisting of mirrors and ground glass plates.³⁶ Similar versions using the same concept were used by different camouflage teams. The Camoufleurs Laboratory of the Second District led by William A. Mackay is worth mentioning here, since—exceptionally—it made use of models in plaster-of-paris, rather than the usual wooden ship models.³⁷

Fig. 12

An American Camouflage Section following the British example was established in early 1918, led by painter Everett L. Warner and physicist Lloyd A. Jones. It consisted of a design subdivision—manned by artists—and a research subdivision at the Eastman Kodak Company in Rochester, New York.³⁸ Their testing facility housed a shallow 4-meter-diameter water basin on which a translucent dome was lighted from the outside to simulate different lighting conditions. Inside, a single lamp on a metal arm could be arranged in such a way that it created any desired solar position. Floating ship models were observed through a cabin mounted periscope. This cabin was arranged on a lorry that could be moved along a track at preset speeds, reproducing the effect of ships moving relative to the periscope.³⁹ Mackay also conducted outdoor experiments, using cut-out ship contours measuring about 1.5 meter, that were suspended from a steel framework placed on lake Ontario. The contour models could then be adjusted in such a way that they seemed to float on the water.⁴⁰ Models would be studied through a ‘visibility meter’, a telescope-like device designed by Jones and patented by Eastman Kodak. It was equipped with interior lighting to fine-tune the amount illumination level to a degree that the observed model would blend in with the background and empirical data could be derived.⁴¹

Fig. 13

The observation through optics was soon followed by model photography as an analytical tool.⁴²

Photographed models—in bird's eye view for target bombing or on eye level for commando raids—in turn would become an essential part of mission briefings during World War II.⁴³ The practice of military model photography bears at this point a certain resemblance to the rise of architectural model photography in the early 1920's, when Ludwig Mies van der Rohe started reworking his famous glass skyscraper designs conducting photo analysis on models and thus instigated a long lasting revolution in the relationship between models, buildings and photographs.⁴⁴

INNOVATION, DISPLACEMENT AND THE INVISIBLE

Military model making was not a new business during the First World War, nor would it come to an end after the Armistice. However, the availability of new intelligence sources provided by new technologies for new types of warfare, boosted the production of models and at the same time diversified their nature, scale and implementation. In the same way that aerial warfare created the need of the faux Paris, new artillery tactics and combined operations demanded specific terrain models and the introduction of submarines required the model testing theatres. The existence of specialized model creating units would be fully exploited in the Second World War, when the widespread use of scale models—mass-produced by manpower as well as machines that were prototyped at the end of the Great War—would become standard practice.⁴⁵

Thus, the progress of technology and the unseen vastness of the *Materialschlacht* paved the way for a technical and scientific approach of warfare—an aspect that can be perceived in most shown examples—maybe best in the case of the dazzle testing theatres. The encapsulation of the model as research object in a laboratory and looked at through an optical device is significant. It can hardly be called coincidence that a manufacturer of lenses and optical materials—i.e. Kodak Eastman—was involved in the development of countermeasures against submarines carrying state-of-the-art periscope optics and binoculars produced by

companies such as Zeiss and Leitz. From the previous examples, it is obvious that war was waged on a variety of scales and that its theatre was far from limited to the battlefield itself. The scale model represents exactly this idea: it is a means to capture, displace and comprehend its scaled content, making the invisible visible—in the context of tactical overview and intelligence—or the other way around in the case of camouflage.

NOTES

¹ For a more detailed description of the faux Paris, see Xavier Boissel, *Paris est un leurre. La véritable histoire du faux Paris* (Paris: Éditions Inculte, 2012).

² A comprehensive study of the living conditions in Ruhleben is found in Matthew Stibbe, *British civilian internees in Germany : the Ruhleben camp, 1914-1918* (Manchester ; New York: Manchester University Press, 2008).

³ Geoffrey C. Pether, "Letters from Geoffrey Pether to his family 1914-1917." *South Petherton Information*. July 25, 2015. <http://www.southpethertoninformation.org.uk/> (accessed December 12, 2015), 16.

⁴ Massimo Scolari, *Oblique drawing : a history of anti-perspective* (Cambridge, Mass.: MIT Press, 2012), 165.

⁵ Ibid., 313.

⁶ Ibid., 287-322.

⁷ Ibid., 287.

⁸ Isabelle Warmoes, *Le musée des Plans-Reliefs* (Paris: Éditions du Patrimoine, Centre des Monuments Nationaux, 1997), 7.

⁹ Ibid., 8.

¹⁰ Ibid., 15.

¹¹ Ian F.W. Beckett, *The Great War, 1914-1918* (Harlow ; New York: Longman, 2001), 260.

¹² Jean-Louis Cohen, *Architecture in uniform. Designing and Building for the Second World War*, (Paris : Éditions Hazan, 2011), 189-190.

¹³ Boissel, *Paris est un leurre*, 14.

¹⁴ Pierre M. Gallois, *Quand Paris était ville-lumière*. Lausanne: Age d'homme, 2001. Cited in Boissel, *Paris est un leurre*, 15, translation by author.

¹⁵ Boissel, *Paris est un leurre*, 15-16.

¹⁶ Alistair Horne, *The price of glory : Verdun 1916* (London: MacMillan & Co, 1962), 309.

¹⁷ Philip Warner, *The Zeebrugge raid* (London: W. Kimber, 1978), 89.

¹⁸ Cécile Coutin, *Tromper l'ennemi: L'invention du camouflage moderne en 1914-1918* (Paris: Éditions Pierre de Taillac et Ministère de la Défense, 2012), 117-138.

¹⁹ Martin Brown, "The battlefield in miniature, or the multi-locational town of Messines," in *Beyond the dead horizon : studies in modern conflict archaeology*, by J. Saunders Nicholas, 71-84 (Oxford; Oakville: Oxbow Books, 2012), 72.

²⁰ Tom Burke, *The 16th (Irish) and 36th (Ulster) Divisions at the battle of Wijtschate - Messines ridge, 7 June 1917 : a battlefield tour guide* (The Royal Dublin Fusiliers Association, 2007), 217.

²¹ Franky Bostyn, Kristof Blicck, and Freddy Declerck, *Passchendaele 1917 : the story of the fallen and Tyne Cot Cemetery* (Roeselare: Roularta Books, 2007), 141.

²² Martin Brown, and Kirsty Nichol, *Messines model, Cannock Chase Staffordshire : excavation and survey 2013* (Unpublished excavation report, No-Man's-Land for Staffordshire County Council, 2013), 10.

²³ Martin Brown, "The battlefield in miniature, or the multi-locational town of Messines," 74.

²⁴ For a detailed description of the model, its context and its excavation, see Martin Brown, and Kirsty Nichol, *Messines model, Cannock Chase Staffordshire : excavation and survey 2013*.

²⁵ For an elaborate case study on Messines Ridge, see Peter Doyle, Matthew Bennett, Roy Macleod, and Louise Mackay, "Terrain model and the Messines Ridge, Belgium, 1914-1918," in *Fields of battle : terrain in military history*, by Peter Doyle and Matthew Bennett, 205-224 (Dordrecht ; London: Kluwer Academic, 2002).

²⁶ Peter Chasseaud, "British, french and German mapping and survey on the Western Front in the First World War," in *Fields of Battle : terrain in military history*, by Peter Doyle and Matthew Bennett, 171-204 (Dordrecht ; London: Kluwer Academic, 2002), 171.

²⁷ Peter Chasseaud, *Artillery's astrologers : a history of British survey & mapping on the Western Front 1914 – 1918* (Lewes: Mapbooks, 1999), 223.

²⁸ Ibid., 158.

²⁹ Peter Chasseaud, "British, french and German mapping and survey on the Western Front in the First World War," 188, 195.

³⁰ Harrison P. Reed, "The Development of the Terrain Model in the War," *Geographical Review* 36, no. 4 (1946): 650-651.

³¹ Dianne Rutherford, "Teaching the terrain : First World War battlefields at the Australian War Memorial," *The Globe*, no. 55 (2004): 25-30.

³² Peter Chasseaud, *Mapping the First World War : the Great War through maps from 1914-1918* (Glasgow: Collins, 2013), 234.

³³ Philip Warner, *The Zeebrugge raid*, 46.

³⁴ For a general introduction to the subject of dazzle painting, see Albert Roskam, *Dazzle Painting: Kunst als Camouflage, Camouflage als Kunst* (Venlo: Stichting Kunstprojecten en Uitgeverij Van Spijk, 1987).

³⁵ Ibid., 24-26.

³⁶ Leo S. Blodgett, *Ship Camouflage*. Cambridge: M.S. Thesis, Department of Naval Architecture and Marine Engineering (Massachusetts Institute of Technology, 1919), 3-6.

³⁷ Roy R. Behrens. *Ship Shape, a Dazzle Camouflage Sourcebook : an Anthology of Writings about Ship Camouflage during World War I* (Dysart, Iowa: Bobolink Books, 2012), 72-73.

³⁸ Roy R. Behrens, "The role of artists in ship camouflage during World War I." *Leonardo* (MIT Press) 32, no. 1 (1999): 56.

³⁹ Roy R. Behrens. *Ship Shape, a Dazzle Camouflage Sourcebook*, 248-251.

⁴⁰ Roy R. Behrens. *Ship Shape, a Dazzle Camouflage Sourcebook*, 137.

⁴¹ Roy R. Behrens. *Ship Shape, a Dazzle Camouflage Sourcebook*, 143-144.

⁴² Leo S. Blodgett, *Ship Camouflage*, 26.

⁴³ Harrison P. Reed, "The Development of the Terrain Model in the War," 633.

⁴⁴ Oliver Elser, "On the history of the architectural model in the 20th century," in *The architectural model : tool, fetish, small utopia*, by Oliver Elser and Peter Cachola Schmal (Frankfurt: Deutsches Architekturmuseum, 2012): 13-14.

⁴⁵ See Alastair W. Pearson, "Allied Model Making during World War II." *Cartography and Geographic Information Science* 29, no. 3 (2002): 227-241.

BIBLIOGRAPHY

Beckett, Ian Frederick William. *The Great War, 1914-1918*. Harlow ; New York: Longman, 2001.

Behrens, Roy R. *Ship Shape, a Dazzle Camouflage Sourcebook : an Anthology of Writings about Ship Camouflage during World War I*. Dysart, Iowa: Bobolink Books, 2012.

Behrens, Roy R. "The role of artists in ship camouflage during World War I." *Leonardo* (MIT Press) 32, no. 1 (1999): 53-59.

- Blodgett, Leo S. *Ship Camouflage*. Cambridge: M.S. Thesis, Department of Naval Architecture and Marine Engineering, Massachusetts Institute of Technology, 1919.
- Boissel, Xavier. *Paris est un leurre. La véritable histoire du faux Paris*. Paris: Éditions Inculte, 2012.
- Bostyn, Franky, Kristof Blieck, and Freddy Declerck. *Passchendaele 1917 : the story of the fallen and Tyne Cot Cemetery*. Roeselare: Roularta Books, 2007.
- Brown, Martin. "The battlefield in miniature, or the multi-locational town of Messines." In *Beyond the dead horizon : studies in modern conflict archaeology*, by J. Saunders Nicholas, 71-84. Oxford; Oakville: Oxbow Books, 2012.
- Brown, Martin, and Kirsty Nichol. *Messines model, Cannock Chase Staffordshire : excavation and survey 2013*. Unpublished excavation report, No-Man's-Land for Staffordshire County Council, 2013.
- Burke, Tom. *The 16th (Irish) and 36th (Ulster) Divisions at the battle of Wijtschate - Messines ridge, 7 June 1917 : a battlefield tour guide*. The Royal Dublin Fusiliers Association, 2007.
- Chasseaud, Peter. *Artillery's astrologers : a history of British survey & mapping on the Western Front 1914 - 1918*. Lewes: Mapbooks, 1999.
- Chasseaud, Peter. "British, french and German mapping and survey on the Western Front in the First World War." In *Fields of Battle : terrain in military history*, by Peter Doyle and Matthew Bennett, 171-204. Dordrecht ; London: Kluwer Academic, 2002.
- . *Mapping the First World War : the Great War through maps from 1914-1918*. Glasgow: Collins, 2013.
- Cohen, Jean-Louis. *Architecture in uniform : designing and building the Second World War*. Paris: Éditions Hazan, 2011.
- Coutin, Cécile. *Tromper l'ennemi: L' invention du camouflage moderne en 1914-1918*. Paris: Éditions Pierre de Taillac et Ministère de la Défense, 2012.
- Doyle, Peter, Matthew Bennett, Roy Macleod, and Louise Mackay. "Terrain model and the Messines Ridge, Belgium, 1914-1918." In *Fields of battle : terrain in military history*, by Peter Doyle and Matthew Bennett, 205-224. Dordrecht ; London: Kluwer Academic, 2002.
- Elser, Oliver. "On the history of the architectural model in the 20th century." In *The architectural model : tool, fetish, small utopia*, by Oliver Elser and Peter Cachola Schmal, 11-22. Frankfurt: Deutsches Architekturmuseum, 2012.
- Gallois, Pierre M. *Quand Paris était ville-lumière*. Lausanne: Age d'homme, 2001.
- Horne, Alistair. *The price of glory : Verdun 1916*. London: MacMillan & Co, 1962.
- Pearson, Alastair W. "Allied Model Making during World War II." *Cartography and Geographic Information Science* 29, no. 3 (2002): 227-241.
- Pether, Geoffrey. "Letters from Geoffrey Pether to his family 1914-1917." *South Petherton Information*. July 25, 2015. <http://www.southpethertoninformation.org.uk/> (accessed December 12, 2015).
- Reed, Harrison P. "The Development of the Terrain Model in the War." *Geographical Review* 36, no. 4 (1946): 632-652.
- Roskam, Albert. *Dazzle Painting: Kunst als Camouflage, Camouflage als Kunst*. Venlo: Stichting Kunstprojecten en Uitgeverij Van Spijk, 1987.

Rutherford, Dianne. "Teaching the terrain : First World War battlefields at the Australian War Memorial." *The Globe*, no. 55 (2004): 25-30.

Scolari, Massimo. *Oblique drawing : a history of anti-perspective*. Cambridge, Mass.: MIT Press, 2012.

Stibbe, Matthew. *British civilian internees in Germany : the Ruhleben camp, 1914-1918*. Manchester ; New York: Manchester University Press, 2008.

Warmoes, Isabelle. *Le musée des Plans-Reliefs*. Paris: Éditions du Patrimoine, Centre des Monuments Nationaux, 1997.

Warner, Philip. *The Zeebrugge raid*. London: W. Kimber, 1978.

IMAGE CAPTIONS

Fig.1 Faux Paris, plan fragment of the objective 'B'.

[illustration from L' Illustration, no. 4048 (1920)]

Fig.2 Model by Geoffrey Pether of internee accommodation at Ruhleben internment camp, 1916, scale 1:12.

[London: Imperial War Museum, catalog MOD 536]

Fig.3 Plan-relief of Ypres, 1701, scale 1:600.

[Paris: Musée des plans-reliefs]

Fig.4 Faux Paris, general plan of the objectives 'A', 'B' and 'C'.

[illustration from L' Illustration, no. 4048 (1920)]

Fig.5 Instructional model of the battlefield in the Vimy Ridge sector, 1918, scale 1:50.

[Ottawa: Canadian War Museum, George Metcalf Archival Collection, catalog CWM 19930065-518]

Fig.6 Instructional model of Messines Ridge, 1917, scale 1:50.

[Canberra: Australian War Memorial, catalog E00648]

Fig.7 Terrain model of the battlefield in the Polygon Wood sector, 1919.

[Canberra: Australian War Memorial, image taken from <https://www.awm.gov.au/sites/default/files/polygon-wood-3d-relief-map-1.jpg>]

Fig.8 Australian model workshop, 1919.

[Canberra: Australian War Memorial, image taken from <https://www.awm.gov.au/sites/default/files/3d-map-making.jpg>]

Fig.9 Wax briefing model of the Zeebrugge harbor entrance and Mole, 1918, scale 1:2,500.

[London: Imperial War Museum, catalog MOD 502]

Fig.10 Naval camouflage testing table of Norman Wilkinson's Dazzle Section.

[photo taken from Albert Roskam, *Dazzle Painting* (1987)]

Fig.11 Painted wooden ship model (Type 10DX) of the Dazzle Section.

[London: Imperial War Museum, catalog MOD 2199]






Fig.12 Finished ship models in William Mackay's workshop in Manhattan.

[photo taken from Roy R. Behrens, *Ship Shape* (2012)]

Fig.13 Lloyd A. Jones' testing facility at Eastman Kodak Company Laboratories.

[photo taken from Roy R. Behrens, *Ship Shape* (2012)]

0 1 2 3 K^m

-  Chemins de fer existants
-  Routes existantes
-  Chemins de fer simulés
-  Rues, Places, Carrefours simulés
-  Fausses Gares

